INVESTIGATIONS AND USE OF LR-115 TRACK DETECTORS FOR RADON MEASUREMENTS

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Abstract

Closed passive integrating radon dosimeters based on the use of cellulose nitrate (LR-115 type II) have been developed for assessment of long term radon exposure.

Although on use for several years, the opportunity of the last two EC radon intercomparisons of passive detectors organised at the NRPB was sized to perform deeper investigations on the significance of what is read.

In this context, registration efficiency, calibration factors, linearity tests and lower limit of detection have been investigated for etched track detectors. Furthermore, a fading study was also carried out on LR-115 detectors from different batches. This paper presents and comments the results of these investigations.

KEYWORDS

Nitrate cellulose (LR-115), EC radon intercomparison, calibration factors, fading

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INTRODUCTION

Because radon is the largest contributor to radiation dose to the public, survey of radon levels in homes and buildings are essential to determine the magnitude of average exposures and to identify situations where excessive exposure occur. Such surveys have been and continue to be carried out using passive etched-track detectors exposed over long periods.

Although etched track detectors are simple in principal, it has been found in practise that strict quality control is required to obtain reliable results. In this context, the Laboratory of Dosimetry had the opportunity to participate for the last two EC radon intercomparison exercises of passive detectors held at the NRPB to evaluate the precision and the significance of radon measurements.

The Nuclear Research Centre of Algiers (NRCA) has used two types of monitors for radon measurements in homes and buildings, one open and the other closed. Both of those dosimeters are based on the use of etched track detectors LR-115 type-II.

The closed type radon gas monitor is described in detail elsewhere (Torri, 1989), two solid state nuclear track detectors, LR-115 type II, having low back ground and low limit of detection, (with an area of 34 x 25 mm^2) are kept together by two covers. The energy of alpha particles from radon and its daughter products are greater than 5 MeV. Therefore a thin foil (20 µm) of aluminised polycarbonate has been introduced between the detectors and the sensitive volume.

The open type radon gas dosimeter is composed with flat casing having in each of its inner faces one nuclear track detector. The sensitive surfaces of these detectors are oriented towards the exterior. When the casing is open the detectors are exposed to the ambient air.

In this work the registration efficiency, sensitivity factors, linearity tests and lower limit of detection have been determined for etched track detectors. The indoor radon concentration was also determined using cellulose nitrate (LR-115 type II films).

EXPERIMENTAL WORKS

Some investigations concerning the response, linearity and a long term stability of track detectors have been performed in the laboratory, before conducting radon measurements in homes and buildings.

Response

Samples of LR-115 type II were irradiated with normally incident beams of alpha particles ranging from 1 to 5.4 MeV. These energies were obtained by degrading a beam of alpha particles from a ^{241}Am source with suitable collimators using Zeigler’s table, TRIM 91 (Biersack and Zeigler, 1992). The energy response of LR-115 type II is shown in Fig.1.

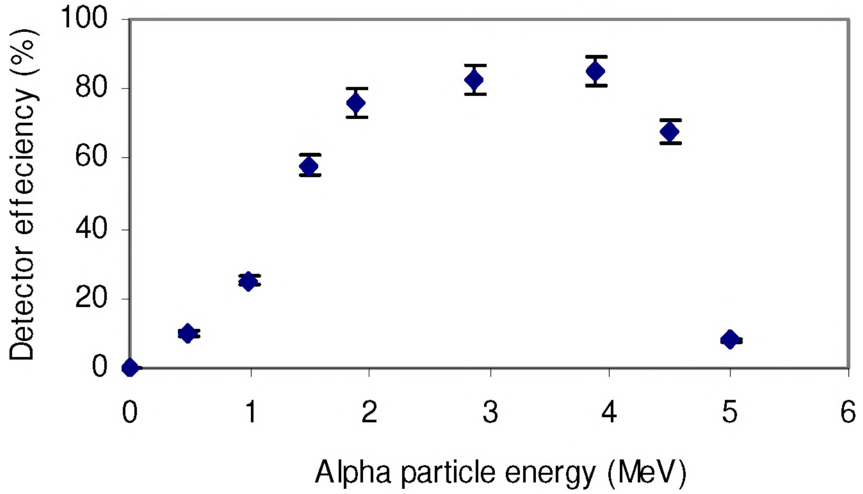

Fig.1. Energy response of LR-115 track detector

Linearity

The linearity of plastic detector has also been studied using the same irradiation source as the previous work. Background as a function of fluence for LR-115 type II detectors is illustrated in Fig.2. As can be seen from this graph, the track density increases linearly with the fluence for this type of track detectors.

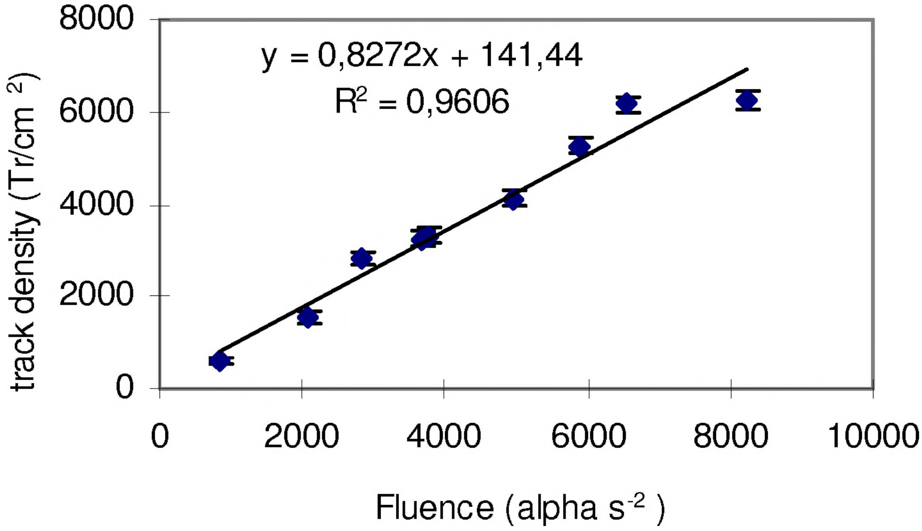

Fig.2. Linearity of LR-115 track detector

Long term stability

The study of background and fading at temperature of 4 °C was performed for track detectors (Kodak films LR-115 type II). Storage periods up to twelve months have been used to investigate changes in background and fading of these plastic detectors. This material sample was investigated as follows: half of the samples (LR-115) from each batch were irradiated with 3 MeV alpha particles, whereas the other half served for the background study. The samples were sealed in polyethylene pouches (1 mm thickness) to minimise effects of environmental alpha radiation. Every two months (5 background and 5 fading) from each batch were chemically etched and counted.

The results reported in Fig.3 indicate that the background density of track detectors increased about 20 % over one year storage. It was also observed in Fig.4 that fading of LR-115 plastic detectors do not vary significantly over one year storage in the laboratory at 4 °C.

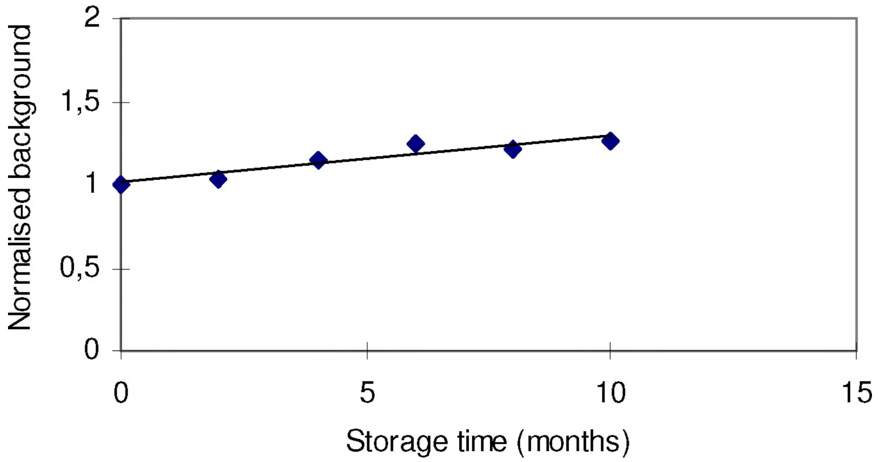

Fig.3. Background of LR-115 type II plastic detector

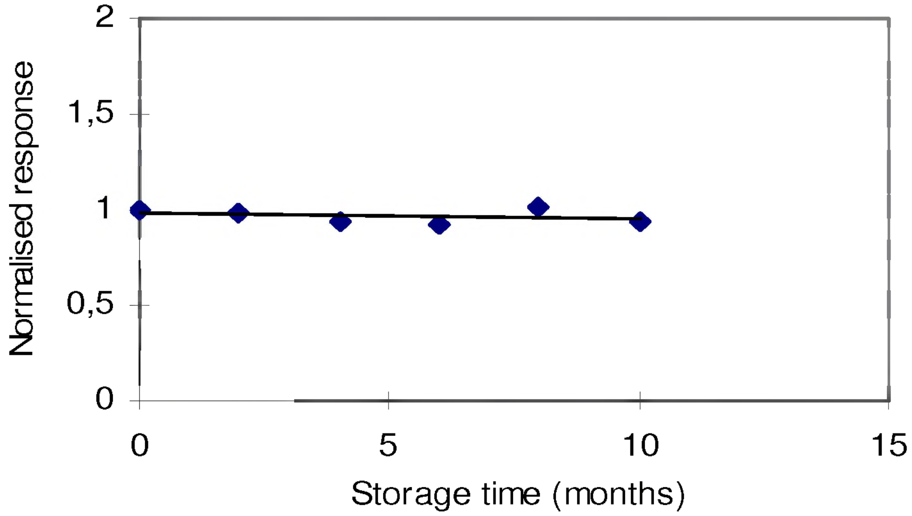

Fig.4. Fading of LR-115I plastic detector

The calibration of the dosimeters was performed at the National Radiological Protection Board (Harwell, U.K.) during the two EC passive radon intercomparisons of 1995 and 1997. Three groups of ten dosimeters have been exposed to three different radon concentrations which were 378, 346, 339 KBq.m^{-3}.h and 227, 294, 312 KBq.m^{-3}.h, respectively, for the years 1995 and 1997.

After exposure the detectors were processed under the usual laboratory conditions. The number of registered alpha tracks was counted by means of an optical microscope and spark counter. The number of track.cm^{-2} (determined for each case) was related to the radon concentration giving the sensitivity factors (F) expressed in tracks.cm^{-2}/KBq.m^{-3}.h.

As it was known in the literature, the calibration factors (F) of closed and open radon monitors on the use of LR-115 were determined using the following relationships, respectively.

$$F = \frac{D_m}{Ct} \qquad (1)$$

$$F = \frac{A}{Ct} \qquad (2)$$

Assuming valid the Poisson statistics, the lower limit of detection (LLD) can be related to the area of detector counted, *S*, as in the following relationship (Currie, 1968):

$$LLD = 4.66\frac{\sqrt{\rho.S}}{F.S} \qquad (3)$$

Where ρ is the background track density and F is the sensitivity factor per unit exposure, C is the radon concentration ($Bq.m^{-3}$), t is the exposure period (h), D_m represents the track density counted with spark counter ($Tr.cm^{-2}$), A is the measured track density with an optical microscope ($Tr.cm^{-2}$) . the results of sensitivity factors and LLD are represented in Table 1.

Table 1. Sensitivity factors and LLD of LR-115 detectors in both closed and open radon dosimeters.

Type of radon Dosimeter	LR-115 type II plastic detector	
	Sensitivity factor ($Tr.cm^{-2}/KBq.m^{-3}.h$)	LLD ($KBq.m^{-3}.h$)
Closed radon dosimeter	1.41±0.15	17.49
Open radon dosimeter	1.86±0.33	9.73

APPLICATION

Around 1000 closed type dosimeters were employed for radon measurements in homes and buildings in Algiers and its neighbouring towns. Those detectors were exposed for periods of two months over one year to evaluate the average of radon exposure. The radon concentration has been determined using the appropriate sensitivity factor. The results of those measurements are illustrated as histogram in Fig.5.

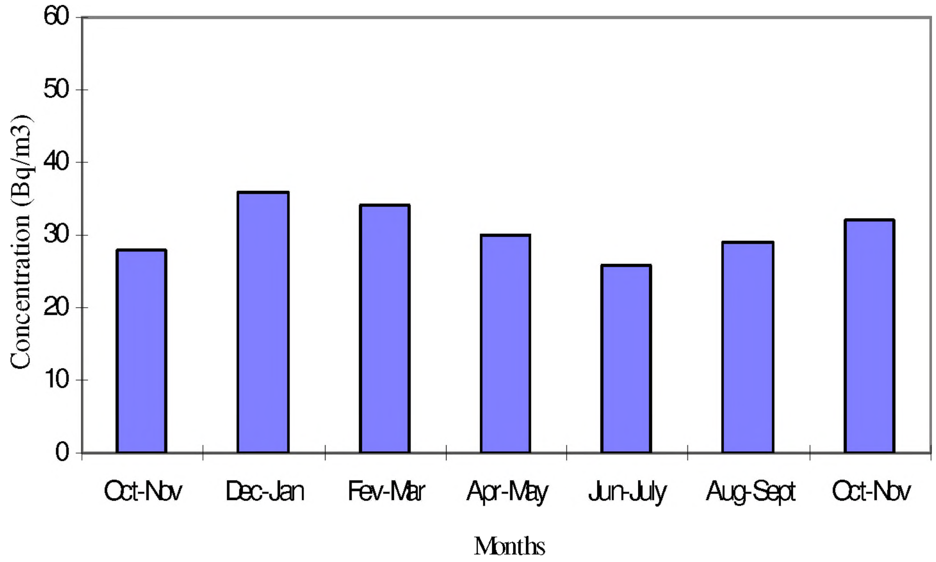

Fig.5. Radon concentration variation in over one year in Algiers

CONCLUSION

Such exercises on radon intercomparison have many scientific advantages such as check on the international comparability of radon measurement results and on their quality control procedures.

Passive detectors have been used as integrating radon measurements in homes and buildings because of their good energy response over a relatively long storage time.

The mean radon concentration obtained over one year using adequate sensitivity factor was around 31 $Bq.m^{-3}$ with a variation of 28 % on seasonal basis for LR-115 etched track detector.

The detector materials used showed a seasonal trend of lower level of radon concentrations during the summer months and higher levels during the winter months.

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